this explanation for the plateau effect depends on a quantized state in the emitter depression being at roughly the same energy as the QWS, so that current can flow from the emitter state to the QWS.

To verify that the plateau is due to an alignment of quantized energy states, the transfer-matrix method (TMM) capability of SQUADS is used to locate resonant energy levels in the device. Rather than searching for energy states at $E > 0$ where a peak in the transmission coefficient occurs, the TMM is modified to find resonant energies at $E < 0$, corresponding to wavefunctions with the highest standing-wave amplitudes in the emitter depression and quantum well. Using this approach, Figure 5 shows the resulting energy spectrum (normalized wavefunction amplitude versus energy) of carriers in the emitter depression (solid curve) and quantum well (dashed curve) for RTD operation at the center of the plateau (0.28 V). The first discrete emitter state (DES) energy is only about 5 meV below the QWS energy, which is close enough for these states to interact and transmit a significant current.

Note that the DES and QWS energies are separated by only 5 meV at the center of the plateau, yet the plateau extends over about 75 mV of applied bias. This requires that the two energy levels stay essentially "locked" together during the plateau portion of the I-V curve: any changes in energy must be virtually equal. This is exactly what occurs: the DES/QWS separation starts at just 8 eV at Va = 0.24 V, and the DES energy increases slowly with applied bias until it rises above the QWS energy at the end of the plateau. In fact, plateau operation is only maintained if the DES is energetically below the QWS. With the QWS above the DES, if the QWS charge density increases, the electrostatic field in the collector barrier increases while that in the emitter barrier decreases, so the potential of the QWS rises further above the DES. This reduces the current flow from DES to QWS, reducing the QWS charge. By symmetry, as the QWS charge decreases, the potential of the QWS decreases towards the DES energy, so the supply of electrons from DES to QWS increases, and the cycle repeats. Thus, a restoring mechanism due to charge storage in the quantum well keeps the QWS slightly above the DES. However, if the DES ever rises above the QWS, the supply of electrons to the QWS decreases, and the QWS begins to deplete. The potential of the QWS drops further below the DES. This further reduces the supply of electrons to the QWS. A run-away conditions ensues, which ends when the lower I-V curve operating conditions are reached.

The fact that the QWS energy does not rise with respect to the collector band minimum indicates that the conduction band profile in the collector and quantum well does not change appreciably through the plateau. Therefore, all increases in applied bias must be accommodated by band-bending in the emitter. Figure 6, which shows the RTD conduction band profile for consecutive biases in the plateau, verifies this. This also indicates that the total charge in the quantum well and collector remains constant throughout the plateau. If the charges changed appreciably, then the electric fields in the device would also be modified, as would the potential profile. Again, plots of total charge in the collector and QW versus applied bias [27] confirm this.

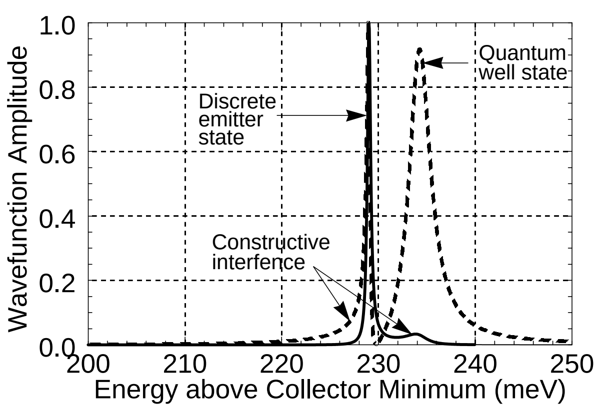

Figure 5: Energy occupation spectrum (normalized wavefunction amplitude versus energy) of carriers in the emitter depression (solid curve) and quantum well (dashed curve) for the conduction band diagram of Figure 4. The first emitter energy level is only about 5 meV below the quantum well state. Constructive interference is apparent near the respective resonant energies, and destructive interference between.

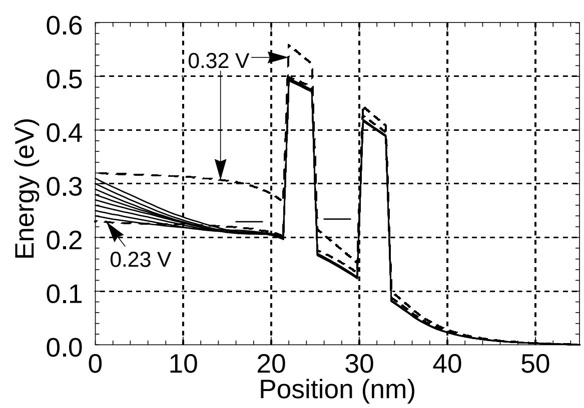

Figure 6: Self-consistent conduction band profile for the plateau (solid curves) and adjacent biases (dashed curves). All applied bias changes in the plateau are accomodated by charging of the emitter contact and discharging of the emitter itself. The resonant states at the center of the plateau (0.28 V) are shown in the emitter depression and quantum well.